Experiencing TI-Navigator in a Calculus Class

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A University of Massachusetts President's Office Professional Development Award provided us the opportunity to class test the TI-Navigator system (developed by Texas Instruments) in a first-year calculus class. Our goal was to test as many of the features of the Navigator system as possible within a two-hour calculus lesson as part of the IMPULSE first-year engineering program at UMass Dartmouth. All classes in this program (Engineering, Physics, and Calculus) are taught in an active learning environment where students work together in teams. A typical class consists of about 40-48 engineering students working in 10-12 teams of four students each. Each team sits at a large table with two computers and each class period is two hours long. This was an ideal environment to test the TI-Navigator system. Figure 1 contains a picture of an IMPULSE classroom.

Figure 1 IMPULSE Classroom

The Mathematics Education Group at UMass Dartmouth provided us with 24 TI calculators, wireless network hubs, and a laptop with the TI-Navigator software. They also made

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a video of the two-hour class. This video turned out to be very useful in assessing the effectiveness of using the TI-Navigator system in a calculus class. Some of the features of TI-Navigator that we used are listed below.

1. Take a poll of the class — the Quick Poll feature.
   We were able to send a question to all the calculators in the class. Students would enter their response and all responses could then be displayed (projected on a screen) for all to see.

2. Gather data in list form from the students — the List Send feature.
   Using their calculators, students were able to send a list of values (for example, an ordered pair (x, y)) to the instructor's laptop. These points could be plotted and patterns observed.

3. Display a copy of each calculator's screen — the Screengrab feature.
   We were able to download a copy of the display screen of each calculator and project all these display copies together in one image for the entire class to see.
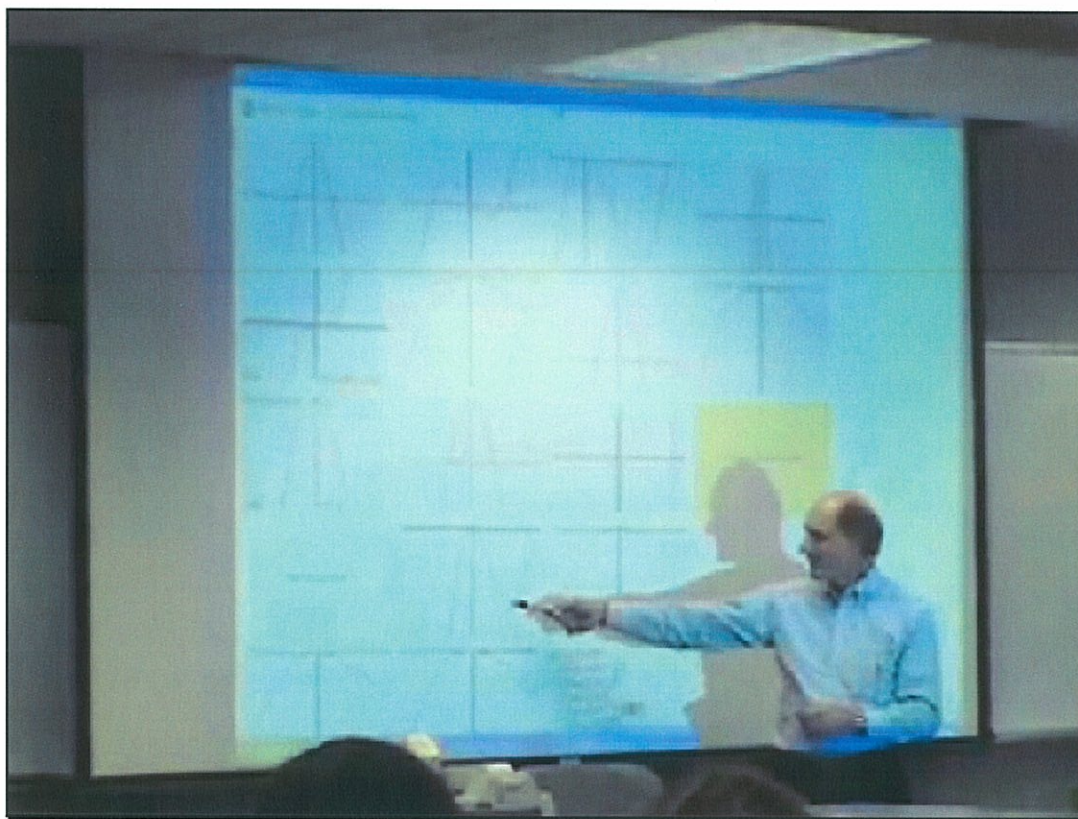

Figure 2 Using the Screengrab Feature

As a warm-up exercise, we asked our students to plot the cubic function $f(x) = x^3 - 25x^2 - x + 25$ in the best viewing window they could find — the default graphing window doesn't work well for this graph. TI-Navigator allowed us to collect and project copies of all twenty-four calculator displays together in one image for the en-

tire class to see (see Figure 2). It was amazing to see the variety of viewing windows that students used — both good and bad.

Since we were studying volumes of revolution, we designed a lesson plan around this topic. The first activity of this lesson was a simple volume of revolution as described below:

Revolve the region bounded by $y = x$, $y = 0$, *and* $x = 1$ *about the x-axis.*

- Poll: *What does the solid of revolution look like?* Answer: *A Cone.*
- Poll: *Find the volume of the solid of revolution. Give your answer to 3 decimal places.*

  Answer: $\dfrac{\pi}{3} = 1.047$.

We used the Quick Poll feature of TI-Navigator in this activity to record all the answers. This was a great start since all students solved this problem correctly. A previous lecture on volumes of revolution did not go to waste.

For the second activity, we wanted to try TI-Navigator's data gathering facility. This activity required all teams to calculate a different volume and send their answer (data) as a list to the TI-Navigator system. A description of this activity is given below:

Let m equal your team number (1-12). Find the volume of the solid generated by revolving the region bounded by $y = mx$, $y = 0$, *and* $x = 1$ *about the x-axis.*

- List Send: *Enter your team number and volume separated by a comma (for example, 3, 1.234) and send it to TI-Navigator.*

Once all students submitted their answers (team number and volume), we used the TI-Navigator to plot all the points and to look for a pattern. At this point we polled the students with the following question:

- Poll: *What type of function do the plotted points represent?*

About half the class responded "exponential" while the other half said "quadratic". This led to a good discussion. The correct answer is quadratic. We then plotted the theoretical model $V = \dfrac{\pi}{3} m^2$ along with the data to test the fit (see Figure 3). Again, all teams correctly found these volumes. It was time to move on to more difficult material.

The next activity was the multi-step problem described below:

Let m equal your team number (1-12). Find the volume of the solid generated by revolving the region bounded by $y = \dfrac{x}{m}$, $y = 5 - \dfrac{x}{m}$, *and* $x = 0$ *about the x-axis.*

We first asked the students to find the point of intersection of the two linear functions $y = \dfrac{x}{m}, y = 5 - \dfrac{x}{m}$ and then did a Quick Poll to check their answers. Next, we asked them
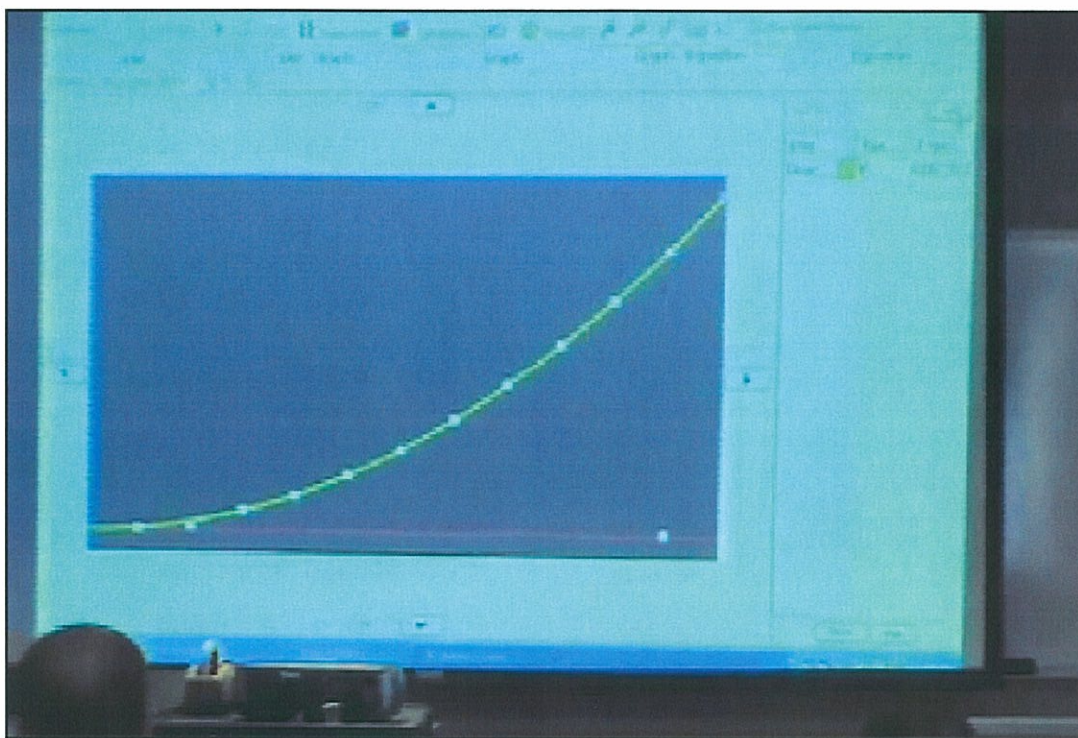
Figure 3 Using the List Send Feature

to calculate the volume of revolution of the enclosed triangular region and then to use the List Send feature of TI-Navigator to submit their answers. This activity resulted in fewer correct answers, but, when the data was plotted, there were enough correct answers to recognized a linear fit (see Figure 4). Students were then asked to calculate the theoretical linear model for this activity. A Quick Poll was taken to allow students to submit their
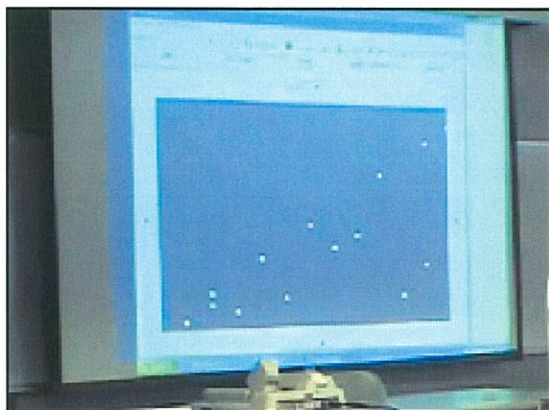

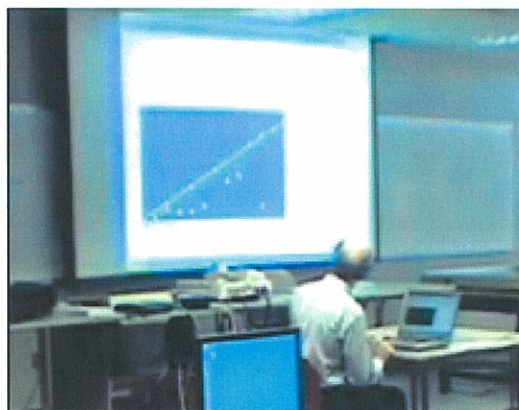**Figure 4 Assessing the Scatter Plot**

Figure 5 Finding the Linear Model

answers. The most common answer was $V = \dfrac{125\pi}{4}m$. This linear model was plotted along with the data to check its fit (see Figure 5).

By gathering students' answers and displaying them, it was easy for the instructor and the entire class to check the understanding of the material of all the students with a quick glance at the plotted data.

It was a fun class and the students were surely motivated. This was probably the most class participation we've ever had in a calculus class. The class whizzed by. A week later, we asked our students to write down their evaluative comments on the class and pass them in (no names — evaluations were anonymous). We were surprised by the well thought out comments we received. Some student comments are listed below.

"I liked the program, it was cool to see how the class as a whole found answers."

"The experiment involving TI Navigator was very helpful in studying volumes of revolution. It gave a visual aid that made interpreting the trends in information easy and clear, The interactive element also makes you feel more connected to the class."

"I enjoyed the program it allowed every one to workout the problem and respond anonymously helping shy people to answer questions and learn more about what they are doing."

"IT WAS fun AND INTERESTING I wish we could do that all day in calculus"

"It allowed everyone to participate in class with less pressure than being called on. While people were participating everyone had an easier time paying attention because they had to focus on getting the answer and inputting it. It was also a little more fun. Something different compared to a usual lecture."

"Tended to be user friendly, but may have slowed work. Guaranteed everyone did work."

"I thought the experience did a good job of showing the ideas using technology. I don't think it is practical for an everyday classroom experience but it was a good change of pace."

"I thought the system was very useful for classroom use. I liked the fact that everyone else answers were available so the teacher could see if the majority of the class understood it and if not could help whoever did not."

"Old fashion (verbal) class participation would have worked just as well. Probably with less confusion and goofing off."

"Nothing beats teaching on the board"